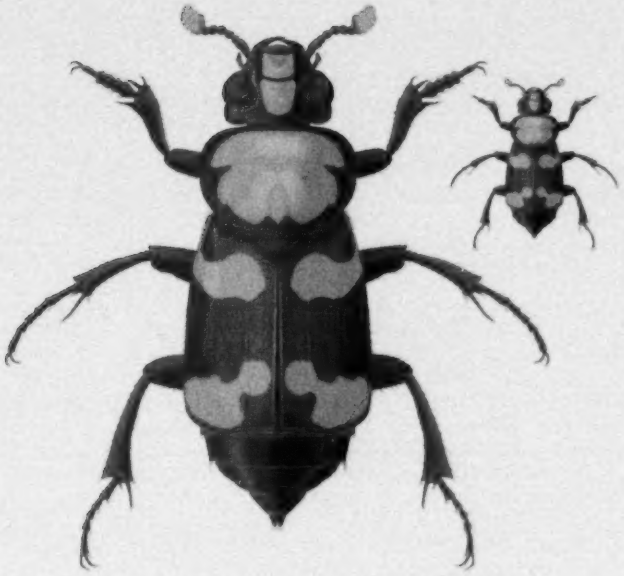
COSEWIC
Assessment and Status Report

on the

American Burying Beetle
Nicrophorus americanus

in Canada



EXTIRPATED
2011

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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COSEWIC
Assessment Summary

Assessment Summary – November 2011

Common name
American Burying Beetle

Scientific name
Nicrophorus americanus

Status
Extirpated

Reason for designation
There is sufficient information to document that no individuals of the wildlife species remain alive in Canada. This includes that it: (1) is a large distinctive and conspicuous insect not seen for 39 generations; (2) has not been seen despite a tenfold increase in the number of field entomologists and an estimated 300,000 general trap nights of which at least some should have resulted in capture of this species, as well as studies of carrion-feeding beetles that did not reveal it; (3) comes to lights yet still not seen in thousands of light traps; and (4) a recent directed search in the general area where last seen 60 and 39 years ago that failed to find this species.

Occurrence
Ontario, Quebec

Status history
Designated Extirpated in November 2011.

COSEWIC
Executive Summary

American Burying Beetle
Nicrophorus americanus

Species information

The American Burying Beetle is a carrion-feeding beetle of the family Silphidae. The species is distinct and there are no proposed subspecies or species forms. It is one of the most striking beetle species in Canada due to its large size and the brilliant orange markings on its otherwise black body.

Distribution

The species occurs only in North America, where its historical range extended from Nebraska and South Dakota east to the Atlantic Coast, and from southern Ontario south to Texas. In the United States it has been reported from 35 states, but it is considered extant in only 9—in all of which it is listed as endangered. In Canada, it is known definitely only from Ontario; however, all reports are historic, with the most recent collection in 1972. Reports for Nova Scotia and Quebec are considered errors, and the basis for the Manitoba report is unknown.

It appears very unlikely that the American Burying Beetle has been present but undocumented anywhere within its range in the last quarter century. Natural re-colonizing by the species of its former range in Canada appears to be very unlikely. The species might be reintroduced from United States populations through captive breeding programs.

Habitat

The species requires well-drained humic or loamy soils without impediments to digging in order to quickly excavate the brood chamber in which to lay its eggs. In eastern North America, soils of this type occur principally in primary, undisturbed deciduous forest. Toward the west side of its range these soils are available in grassland ecotypes as well. There is, as yet, no consensus on whether the species is obligate on particular habitat types.

Biology

The species has one generation over the period of a year, with individuals existing from the summer to their death in the following year. Individuals will typically have the opportunity to reproduce only once. Following emergence from the ground, in the late summer or early fall of the year in which it was laid, the teneral begins feeding and possibly searching for reproductive opportunities. In the fall of their first year they burrow into the ground to overwinter. The adults again emerge in the spring to feed and begin their evening search for a recently deceased suitable brood carcass.

Sexton beetles (genus *Nicrophorus)* show biparental care to a unique degree for beetles. Reproduction is completely dependent upon the availability of a carcass which can be entombed in a manner suitable for feeding larvae. Vertebrate carcasses of any sort are used; however, bird chicks and rodents are probably most often employed. American Burying Beetle tends to use larger carcasses than its smaller congeners. When a suitable carcass is located the individual or pair will compete with other carrion-eating insects for possession of the carcass until a single pair remains. The carcass then may be moved as far as a metre until soil suitable for excavation is reached, then buried before the dawn.

The species is not migratory, and its movements are limited. However, it does range more widely than its smaller congeners (i.e., species of the same genus), and likely across more habitat types. Adults begin their seasonal activities when the temperature exceeds 15°C. They are crepuscular and nocturnal, and generally active from April through September.

Population sizes and trends

It is believed that the species has been extirpated in Canada and from all states coterminous with Canada. It is estimated that there are fewer than 1,000 individuals in the currently disjunct Block Island, Rhode Island, population, and the two western United States populations each contain an unknown, though certainly much larger, number of individuals.

Limiting factors and threats

There is ongoing discussion regarding the cause of the decline in the range and abundance of the American Burying Beetle. There are a number of hypotheses, many of which are unconvincing due to the apparent lack of impact on congeners of similar behaviour and requirements. It seems unlikely that any one factor is responsible for the species' decline.

Direct impacts are thought to have been: the use of artificial lighting, which may affect the species' behaviour, roadkill of wandering adults, and mortality due to the use of insecticides. Species-specific diseases have been considered, but there is no evidence to support this mechanism as likely.

Direct predation seems likely to have played a part, given the increase in appropriate predators over the species' range, but is not thought to be the major cause of the decline either of the species or its supply of brood carcasses. The increase in predacious, free-ranging domestic dogs and cats, which likely disturb carcasses, may be a factor.

Reduction of brood carcass resources may be a major factor. This reduction is thought to have come about due to the decreased populations of species of appropriate size for brood carcasses, and increased competition with scavenging animals and the more abundant congeners. Reduction in the use of waste meat dumps and cessation of using whole fish as fertilizer will also have reduced carrion resources available to the beetles.

Habitat alteration and fragmentation is generally considered to be the primary cause for decline. Fragmentation increases the need for species' movement across unsuitable habitats and over roads. The development of dense understory in cleared forest areas increases the difficulty of burying the brood carcass, and hence the vulnerability of the beetle pair to predation.

Special significance of the species

The species offers a rich resource for behavioural study, particularly as it is a member of one of the few insect groups that exhibit parental behaviour. Having been recognized as having suffered an extraordinary and presumably anthropogenic decline, the species offers the potential for enlightenment regarding human impacts on invertebrate species, and other ecological subjects. As a representative of the invertebrate megafauna, with intriguing behaviour, the species has great potential for bringing the plight of lesser-known organisms to the public eye.

Existing protection or other status designations

Globally, the American Burying Beetle is listed in the IUCN Red List as Critically Endangered, based on a population reduction of ≥90% and a decline in area of occupancy and occurrence. The species was listed as an Endangered Species federally in the United States through the *U.S. Endangered Species Act* in August 1989, based on the drastic decline and extirpation of the species over nearly its entire historical range. NatureServe lists the species as globally imperiled. The species has not yet been assessed under the National General Status protocols for Canada.

TECHNICAL SUMMARY

Nicrophorus americanus
American Burying Beetle — Nécrophore d'Amérique
Range of Occurrence in Canada: southern Ontario, southern Quebec

Demographic Information

Generation time (average age of parents in the population)	1 year
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 or 5 years, or 3 or 2 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	Unknown
Are the causes of the decline understood?	In part
Have the causes of the decline ceased?	No
[Observed, inferred, or projected] trend in number of populations	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown
Are there extreme fluctuations in number of populations?	Unknown

Extent and Area Information

Estimated extent of occurrence	0
[Observed, inferred, or projected] trend in extent of occurrence	Not applicable
Are there extreme fluctuations in extent of occurrence?	Not applicable
Index of area of occupancy (IOA)	0
[Observed, inferred, or projected] trend in area of occupancy	Historic decline to extirpation
Are there extreme fluctuations in area of occupancy?	Not applicable
Is the total population severely fragmented?	Not applicable
Number of current locations	None
Trend in number of locations	Historic decline to extirpation
Are there extreme fluctuations in number of locations?	Not applicable
Trend in [area and/or quality] of habitat	Decline

Number of mature individuals in each population

Population	N Mature Individuals
Total	
Number of populations (locations)	Presumed to be 0

Quantitative Analysis

	Not available

Threats (actual or imminent, to populations or habitats)

Prior threats likely included subsidized predators, habitat loss and fragmentation, and increasing roads.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? U.S.: Endangered both nationally and in each extant state	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Unknown
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Designated Extirpated in November 2011.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Extirpated	none
Reasons for designation: There is sufficient information to document that no individuals of the wildlife species remain alive in Canada. This includes that it: (1) is a large distinctive and conspicuous insect not seen for 39 generations; (2) has not been seen despite a tenfold increase in the number of field entomologists and an estimated 300,000 general trap nights at which at least some should have resulted in capture of this species, as well as studies of carrion-feeding beetles that did not reveal it; (3) comes to lights yet still not seen in thousands of light traps; and (4) a recent directed search in the general area where last seen 60 and 39 years ago that failed to find this species.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable since no definite data on declines which occurred more than 50 years ago.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable since no distribution range is known.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable since no mature individuals are known.
Criterion D (Very Small Population or Restricted Distribution): Not applicable since no populations known.
Criterion E (Quantitative Analysis): None available

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2011)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

American Burying Beetle
Nicrophorus americanus

in Canada

2011

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SPECIES INFORMATION

Name and classification

Kingdom: Animalia – animais, animaux
Phylum: Arthropoda – arthropods, arthropodes
Subphylum: Hexapoda – hexapods
Class: Insecta – hexapods, insects, insectes
Subclass: Pterygota – winged insects, insects ailés
Infraclass: Neoptera – modern wing-folding insects
Order: Coleoptera Linnaeus 1758 – beetles, coléoptère
Suborder: Polyphaga Emery 1886
– leaf, longhorn, rove, scarab, snout, and water beetles
Infraorder: Staphyliniformia Lameere 1900
Superfamily: Staphylinoidea Latreille 1802
– carrion, fungus, and rove beetles
Family: Silphidae Latreille 1807 – carrion beetles
Subfamily: Nicrophorinae Kirby 1837
Genus: *Nicrophorus* Fabricius 1775 – sexton beetles
Species: *Nicrophorus americanus* Olivier 1790*
English Name: American Burying Beetle
French Name: Nécrophore d'Amérique

The American Burying Beetle is a large insect of the order Coleoptera, the largest order of insects, with over 350,000 described species. It belongs to the carrion beetle family (Silphidae), and the genus *Nicrophorus* (sexton or burying beetles). The genus has been taxonomically stable since its description, although *Necrophorus*, an old junior synonym, is occasionally still used. There are about 70 species worldwide, and 15 species in North America—*N. americanus, N. carolinus* (Linnaeus, 1771), *N. defodiens* Mannerheim 1846, *N. guttula* Motschulsky, 1845, *N. hybridus* Hatch and Angell 1925, *N. investigator* Zetterstedt 1824, *N. marginatus* Fabricius 1801, *N. mexicanus* Matthews 1888, *N. nigrita* Mannerheim 1843, *N. obscurus* Kirby 1837, *N. orbicollis* Say 1825, *N. pustulatus* Herschel 1807, *N. sayi* Laporte 1840, *N. tomentosus* Weber 1801, and *N. vespilloides* Herbst 1783.

The species is distinct and there are no proposed subspecies or species forms. It may be related to the similarly large *N. germanicus* (Linnaeus, 1758) of Europe. The species synonymy is: *N. grandis* Fabricius 1792, *N. orientalis* (Herbst 1784), and, *N. virginicus* Frölich 1792. In literature, the species is likely to be confused with another valid carrion beetle species *Necrophilia americana* (Linnaeus 1758), the American Carrion Beetle, a flattened black species with a white-edged thorax.

The English name American Burying Beetle is historical and the dominant name in current usage; however, Giant Carrion Beetle is sometimes used. The French name is a tentative proposal made for this report (P.M. Brunelle).

* IUCN (2009) erroneously gives the date of description as 1890.

Morphological description

See Figure 1 for an image of an adult male. The American Burying Beetle is one of the largest beetles in Canada, and the largest of the 15 species of its genus in North America, ranging from 25 to 35 mm in length. Some authorities give the maximum size as 45 mm, possibly in error. It can readily be identified to species by size and markings.

Determination to genus within the family Silphidae is by the body not being dorso-ventrally compressed or flattened, elytra (hardened front wings which form a dorsal shell when retracted) usually with substantial orange markings, with virtually straight posterior margins, which do not cover 3 or 4 of the posterior segments of the abdomen.

The species is largely ebony, with two large pumpkin orange patches on each of the two elytra, a large orange patch on the raised portion of the pronotum which is unique in the genus and hence diagnostic to species (the pronotum is a large plate just behind the head and before the elytra, also referred to as the pronotal disk), and further orange markings on the dorsum of the head and at the apices of the antennae.

The female resembles the male except in the form of the anterior orange patch on the clypeus at the front of the head (also referred to as the frons). This orange patch is small and triangular with the median apex posterior in the female, and that of the male being large and rectangular or broadly rounded posteriorly.

The larvae are vermiform (worm- or caterpillar-like), white and sparsely marked with orange on the top of each segment. The orange markings are heavier on the front segments and head.

Genetic description

Szalanski *et al.* (2000) evaluated the genetics of the species in five U.S. states, ranging from Rhode Island west to Nebraska, and found "little evidence that these 5 populations have maintained unique genetic variation". It is not reported that the Canadian specimens have been tested genetically.

Designatable units

The Canadian population is regarded as a single designatable unit. The species was only found in one ecoregion. There is no information suggesting discrete groupings.

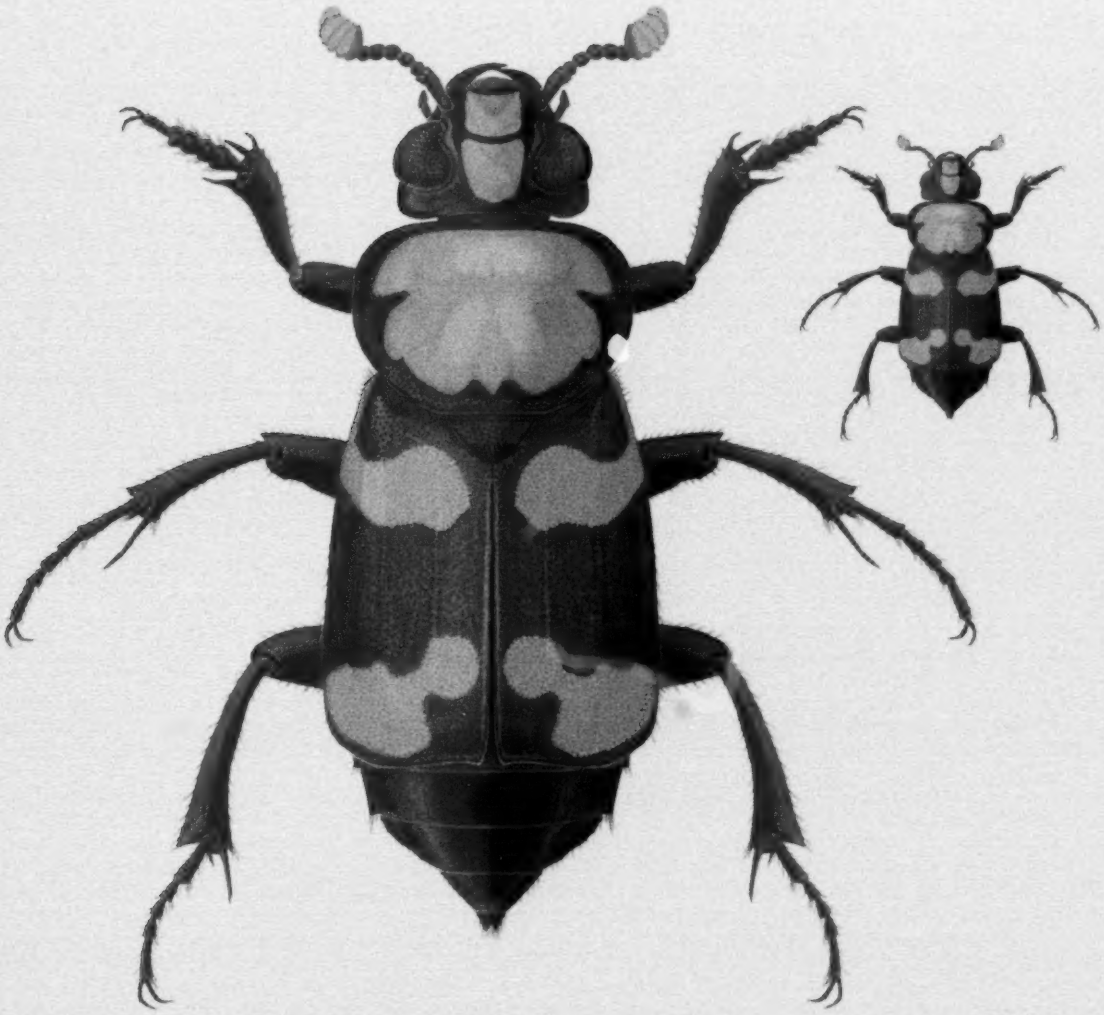

Figure 1. A male of the American Burying Beetle. The small figure shows maximum reported life size. Illustration made by P.M. Brunelle based on specimens examined.

DISTRIBUTION

Global range

See Figure 2 for the global range. Source: (Raithel 1991).

The American Burying Beetle is endemic to North America. It is historically known from west-central Nebraska and South Dakota east to Maine. The most northern historical report is from the Upper Peninsula of Michigan, and the most southern historical report is from Kingsville, southern Texas (Raithel 1991). There is a substantial outlier in the continental distribution, a report from Montana which has been ranked SNA (ranking applicable), *"possible resident, not documented"*, and hence is suspect (MTGOV 2009).

Historically reported range

The historical east to west range of the species is about 2,500 km (about 30.5°), from Massachusetts (about -70.5°W) to middle South Dakota (about -101°W), excluding the Montana outlier (about -108°W). The historical north to south range is about 2,100 km (about 19°), from upper Michigan (about -46.5°N) to southern Texas (about -27.5°N).

In the United States the species has historically been reported from 35 states but is known to be still present in the wild in only eight—Arkansas, Kansas, Massachusetts (reintroduced), Nebraska, Oklahoma, Rhode Island, South Dakota, and Texas (Raithel 1991), in all of which it is ranked as at high risk. NatureServe (2009) does not list the species for Iowa, Montana, and New Hampshire, apparently oversights. Reintroductions in Ohio since 1998 have apparently been successful (USDA 2008).

Current known range

The historical known range on the continent (Figure 2A) has been reduced to an estimated 10% or less (Figure 2B, NatureServe 2009). The decline is believed to have begun in the 1920s.

The species is now known in the wild only from three widely separated populations. The only contemporary natural population east of the Mississippi River is on Block Island, off the southern coast of Rhode Island, where the species is apparently stable. Occurrences in Ohio (USDA 2008) and Massachusetts (Amaral *et al.* 1997) are both reintroductions. In approximately the centre of the continent there are two large natural populations. The species is reported from a large area of central Nebraska and a small area of adjacent South Dakota. There is also a substantial range in a large area of eastern Oklahoma, with small areas of Kansas to the north, Missouri and Arkansas to the east, and the very northeastern edge of Texas (Kozol *et al.* 1988; Raithel 1991; Godwin and Minich 2005).

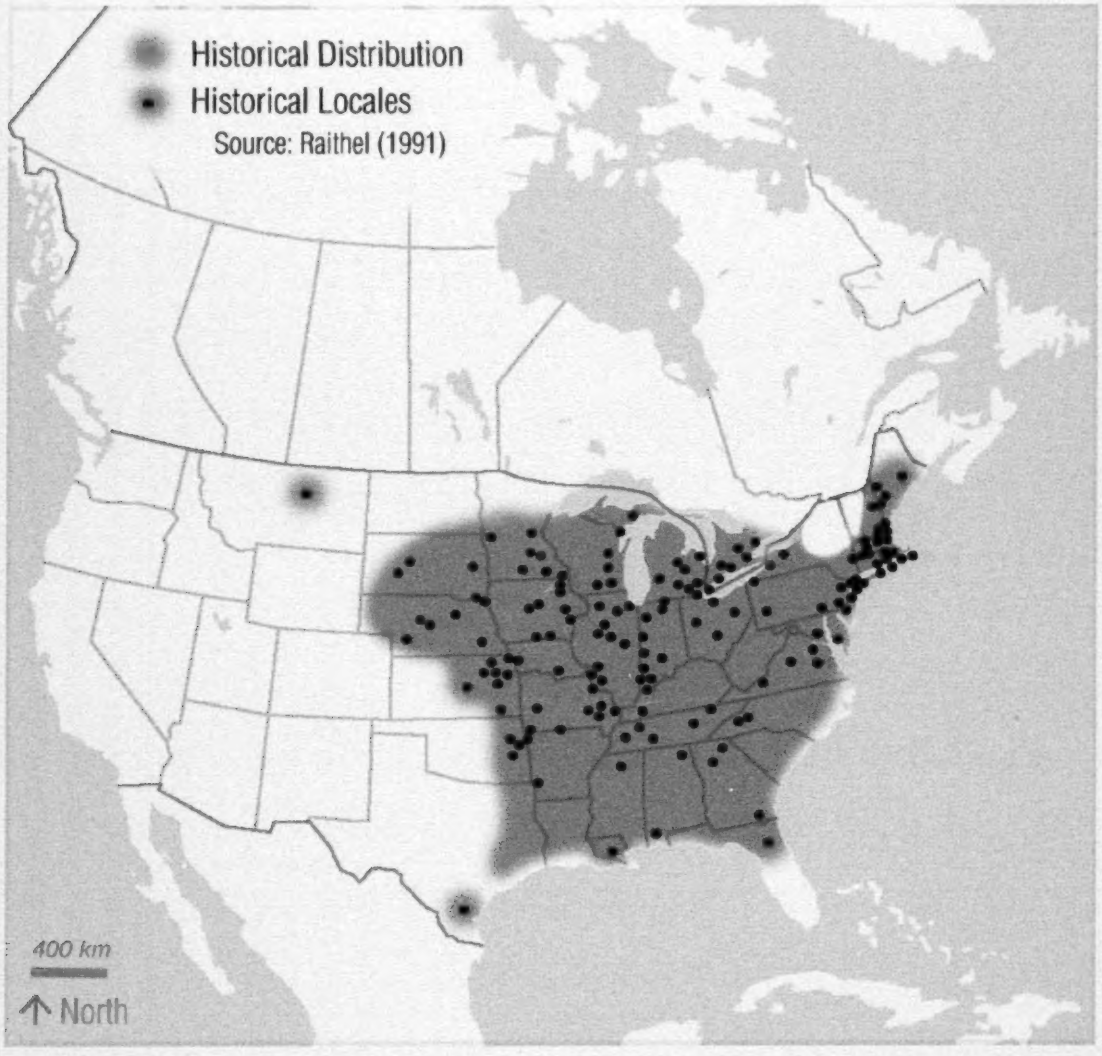

Figure 2A. Historical range of the American Burying Beetle. Source: P.M. Brunelle, after Raithel (1991) and Lomolino *et al.* (1995).

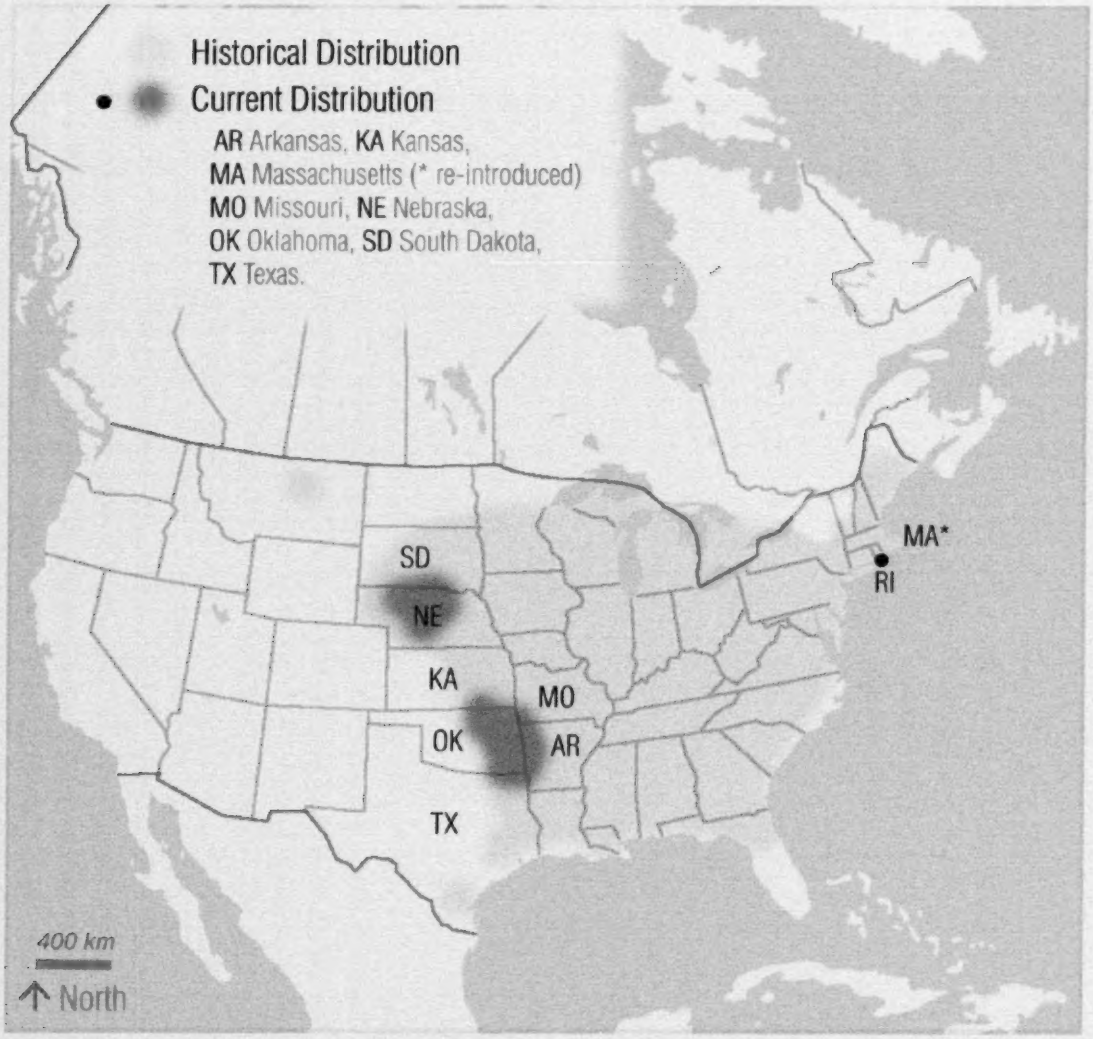

Figure 2B. Contemporary range of the American Burying Beetle. Source: P.M. Brunelle, after Raithel (1991) and Lomolino *et al.* (1995).

Canadian range

See Figure 3 for the historic distribution of the species in Canada (source: P.M. Brunelle). See Appendix 1 for details of all known Canadian records of the species. The species has been historically reported from four provinces—Nova Scotia, Manitoba, Quebec, and Ontario.

The report for Nova Scotia is generally considered to have originated in an error in Madge (1956), although it persists in some data holdings. The report for Manitoba (NatureServe 2009) is SNR (unassessed) and unsubstantiated (see Appendix 1).

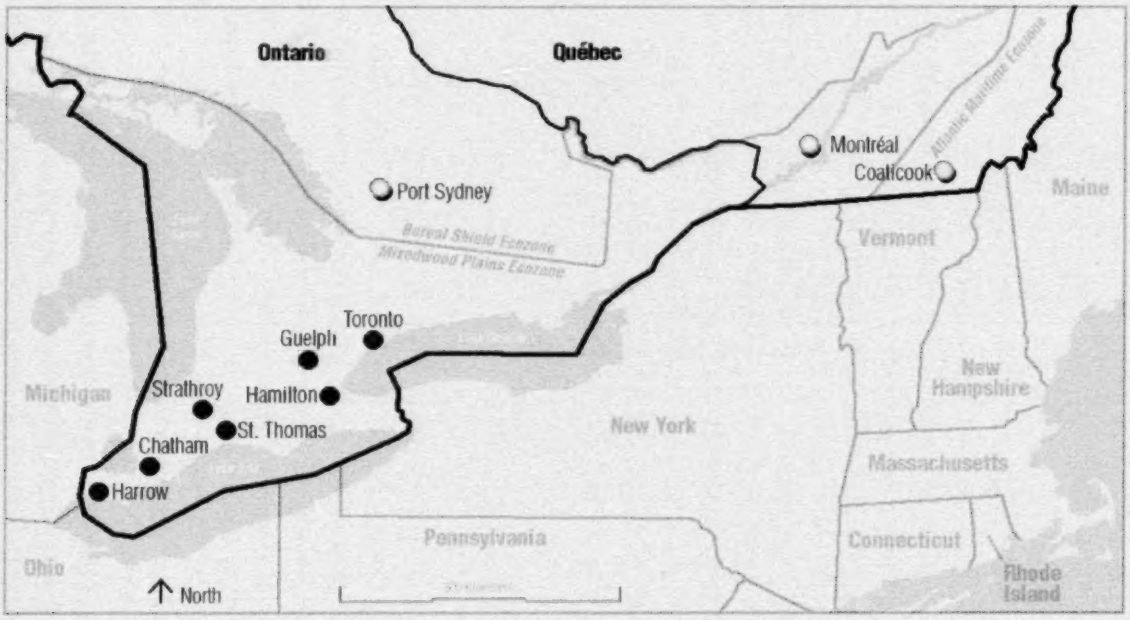

Figure 3. Historic Canadian range of the American Burying Beetle (dots) and reports that are questionable (circles). Source: P.M. Brunelle and see Appendix 1.

In Ontario, the species is reported from eight sites: Chatham (1930, 1936), Guelph (1930), Hamilton (no date), Harrow (1951, 1972), Port Sydney (no date), Strathroy (1934), St. Thomas (1925), and Toronto (1896); the most recent report being 1972 (Harrow). The Ontario Natural Heritage Information Centre for NatureServe (2009) has ranked the species as SH (historical). The specimens in CNC and other collections that are the basis for these records were examined by Anderson and Peck (1985) for their monograph.

In Quebec, the species is reported from two sites, Coaticook near Sherbrooke, and Montréal, the most recent report being 1913 (Coaticook). There is no specimen to support the Montréal occurrence and although the specimen allegedly from Coaticook is correctly identified, Beaulne's collections are suspect as a result of other collections made by him on the same day at distant localities. Following biologists in Quebec and the Quebec CDC, we are inclined to discount these reports and consider occurrence in Quebec unconfirmed (see also Appendix 1).

Most Canadian reports are from the Mixedwood Plains Ecozone (basically the "Eastern deciduous forest region"), except for that from Port Sydney, Ontario, which is in the Boreal Shield Ecozone, though only about 50 km from its border with the Mixedwood Plains (NSWG 1996).

All reports are in heavily impacted agricultural or urbanized areas, although that might conceivably not have been the case on the dates of encounter. All reports are somewhat vague with respect to location (usually only a town or city is mentioned) and lack habitat descriptions.

The species is unlikely to inhabit large areas of the Boreal Shield and the Atlantic Maritime ecozone, and it appears likely that the American Burying Beetle is extirpated in Canada. The lack of additional records after 1972 of such a conspicuous species, which is highly susceptible to capture by pitfall and light traps, strongly suggests that it has gone from all of its Ontario range. Until 2010, it was hoped that American Burying Beetle was still extant in the Harrow area. However, continued occurrence even in this area now seems very unlikely based on a recent directed search (see below under **Search effort**). Although it was discovered in four additional states in the United States after listing in 1989, these areas were not on temperature-related range limits as was its northern limit in Canada. Based on the northern range limit to the east and west the only Canadian range available would be in southern Ontario.

Search effort and methods

In 2010 fieldwork was carried out to determine if American Burying Beetle was still present within its recent historical range in southern Ontario (Taylor-Pinder *et al.* 2010). This survey utilized optimum and recently developed sampling procedures. The sampling took place from June until mid-September 2010. Sampling events resulted in a total of 281 trap nights at four locations throughout southwestern Ontario. A total of 259 specimens of carrion-feeding beetles of other species were collected in four principal sites representing eight genera and nine species. The most common species caught was the very different *Necrophilia americana* (Linnaeus) and it was found in all localities. This directed search did not yield any individuals of *Nicrophorus americanus*. The areas searched included Point Pelee National Park, Turkey Point Provincial Park and Windsor Prairie (Ojibway Park), which are some of the most diverse and extensive natural areas in the region. Traps were also set at Harrow Agriculture and Agri-Food Canada Research Station, where the beetle was last seen in 1972. This substantial recent unsuccessful search effort in the area where it was last seen supports the idea that it has been extirpated from Ontario. The second most recent record was also from Harrow in 1951. Other habitats (more extensive natural areas in southwestern Ontario) have been surveyed including light trapping and many of the earlier records of this conspicuous species were the result of light traps (see under "**POPULATION SIZES ...**", Anderson and Peck 1985).

Other studies of Silphid beetles in Ontario, both published (e.g., Legros and Beresford 2010) and unpublished, have not been directed to *N. americanus* or to a clarification of its range, but nevertheless have supported its complete disappearance (see also **Search effort** in relation to population trends below).

HABITAT

Habitat requirements

The American Burying Beetle is a terrestrial insect. Since the recognition of the great reduction in its range and abundance, and its subsequent United States federal listing as endangered, there has been a great deal of research on the species, which has led to a greater understanding of its habitat requirements.

Given that the species had a very broad historical range, which crossed many basic landforms and vegetation zones, it is unlikely that it was ever a consistent habitat specialist throughout its range. However, Walker and Hoback (2007) hypothesize based on a mark-recapture study that the advent of dense woody vegetation (*Juniperus virginiana*) in open habitat impacts *N. americanus* by limiting its "ability to forage for carrion."

There appear to be three requirements for viable habitat (Sikes and Raithel 2002): (1) soils sufficiently friable for the excavation of the brood chamber (see **Life cycle**); (2) presence of a sufficient supply of carcasses of the appropriate size; and (3) absence of an overwhelming number of competitors for the carcasses.

It is generally assumed that the species is more generalist in its feeding habitat than in its reproduction (brood chamber) habitat.

Soil characteristics

Nicrophorus americanus, like *N. germanicus*, probably digs its brood chamber to a greater depth than do its smaller congeners (Anderson 1982, see **Life cycle and reproduction**). To complete this substantial excavation quickly in order to avoid competition for the carcass from other carrion-eating animals (see **Interspecific interactions**), the soil must be somewhat loose and moderately humid, and there cannot be large numbers of substantial roots (therefore an absence of dense shrub and small tree understory). For the brood chamber to be structurally sound, the soil cannot be comprised mostly of sand or other friable materials. In addition, the area must be well drained or the chamber would flood.

Anderson (1982) considered the species a habitat specialist in eastern North America, associated with *"mature mesic* [containing a moderate amount of moisture] *forest ecosystems"*, which he also refers to as *"mature climax"*, and *"primary"* forests. This belief was based on his own surveys, the general landforms for reports of the species in Canada (the bulk of the Canadian reports are from the Mixedwood Plains Ecozone), the habitat description in Walker (1957), and comparison with the behaviour and situation of two congeners of comparable size (*N. germanicus* of Europe, and *N. concolor* Kraatz 1877 of China and Japan). Anderson argued that the effort required to dig the brood chamber was a key factor in characterizing required habitat for the species, and that primary forests are the only habitat available in Eastern North America in which the soil characteristics make this excavation practical.

However, Raithel (1991) points out that in the northeastern part of the species' range (Canada and New England), historical collections were made after the clearing of the land for agriculture.

The habitat of the Block Island, Rhode Island, population is glacial moraine deposits vegetated with a post-agricultural maritime scrub plant community (Raithel 1991). This habitat includes large mowed and grazed fields, and dense shrub thickets (ArkansasHabitat 2009). It may be that the former extensive agricultural use of the land, only recently reduced, has modified the soils to be suitable for the beetle. This along with high bird populations including Ring-necked Pheasant (*Phasianus colchicus*), poults may have contributed to the persistence of *N. americanus* there.

In the western states, where most recent research has been done, the species is found in diverse habitats—grasslands, tallgrass prairie, pastures, old field shrubland, deciduous (oak-hickory), and coniferous (pine) forests—all habitats in which the requisite soil conditions seem likely.

Raithel (1991) indicates that the Latimer County, Oklahoma, capture sites were in valleys of the Ouachita Mountains, where all were in pasture and forest/pasture habitats and had soils comprised of loams (fertile soils of clay and sand containing humus). In western Cherokee and eastern Muskogee counties of that state, the species was found in oak-hickory and bottomland forests, and grasslands, with slightly more sampling success in the latter habitat type, and the least success in bottomland forests (possibly due to flooding). Lomolino *et al.* (1995) and Holloway and Schnell (1997) considered the species a habitat generalist with respect to vegetation cover when feeding.

Supply of carcasses

It is probable that the availability of vertebrate carcasses of the appropriate size in a particular area is more important than vegetation cover or soil composition (Raithel 1991). However, these habitat factors obviously influence the presence and abundance of vertebrates, and hence also of competitors for the carcasses. Habitats rich in reproduction in bird and mammal species (death of young vertebrates is the principal source of carcasses) will be better able to support American Burying Beetle populations.

Holloway and Schnell (1997) stated that *"American burying beetles frequented sites where small vertebrates (particularly mammals) were relatively abundant, irrespective of the predominant habitat at that site"*.

The now discontinued practice of using whole fish as fertilizer for fields (Raithel 1991) may have been beneficial to the beetle in Atlantic coastal and Great Lakes areas, and this may possibly account in part for the healthy population on Block Island.

Anthropogenic middens, where pest carcasses such as rats are discarded at ground level or a bit above, may have supported the species until the practice of having personal garbage piles was discontinued, particularly in urban areas. However, excavation of latrines from the 1700s and 1800s have failed to give evidence of the American Burying Beetle, and incidence of any *Nicrophorus* species are very rare (C. Majka, pers. comm. 2003). There seems little reason to expect a difference between 'latrines', and 'middens', the former being areas where waste materials are thrown into a pit, the latter on ground level. Thus the loss of anthropogenic middens seems unlikely to have been significant.

Habitat trends

Anderson (1982) attributed the decline of the American Burying Beetle to *"the destruction of primary forests in the eastern United States and Canada"*. However, it appears that clearing of forests and use of the land for agriculture does not necessarily lead to extirpation of the species if its soil and carrion requirements are met. The major period of land clearing in Ontario occurred in the 1800s when the beetle was still widespread. However, it is unknown if these habitat changes stressed the species, eventually contributing to extirpation through other phenomena.

All areas in Canada in which the species has been reported have some remnants of forest which could still play a part in the life cycle of the species. The degree of fragmentation and small size of the remnants may account for the species' apparent extirpation in Canada.

Loss of suitable carrion has very likely been a factor in decline. Possibly much more important is the decline of certain birds. It has been speculated that the extinction of Passenger Pigeons (*Ectopistes migratorius* (Linnaeus 1766)) around 1900 may have contributed to the decline of *N. americanus*, because these birds were in the ideal

weight range for the species (Sikes and Raithel 2002). The North American population of Passenger Pigeons was at one time 3 to 5 billion, with a density of 5 to 6 birds per acre. Numerous other bird species have declined in North America and this could also have contributed to the decline of *N. americanus*. Although some birds have increased in southern Ontario over the last two decades (bird atlas results—Cadman *et al.* 2007), this may not be of a scale that imparts advantage.

Another threat is that carrion accumulates along the gravelly margins of roads where it cannot readily be buried, possibly attracting the beetles but wasting reproductive effort, and exposing the beetles themselves to the risk of becoming roadkill. A further problem is frequent disturbance of the beetle's burying efforts by subsidized predators such as dogs, cats, raccoons, etc., which have become increasingly numerous (P.M. Catling, pers. comm., 2003). Although the mechanisms of impact are unclear, there can be little doubt that viable habitat for this species has declined substantially.

Habitat protection/ownership

There is no habitat protection in Canada for areas in which the American Burying Beetle has been reported. Various areas where the species is reported in the United States are protected, though none are proximal to Canada.

BIOLOGY

Life cycle and reproduction

Raithel (1991) is the principal reference for life cycle and reproduction. Sexton beetles (genus *Nicrophorus*) show biparental care to a unique degree for beetles, and indeed for most insects. They resemble some groups of the order Hymenoptera and Isoptera in this respect (ants, bees, termites, and wasps), although they do not exhibit highly developed social behaviour (i.e., eusociality). The breeding pair are the greatest species aggregation except when in competition for a brood carcass, or as larvae. Field and laboratory studies have indicated that the biology of *N. americanus* is similar to that of congeners except with respect to the optimal size range of carcasses used in reproduction.

The species has one generation per year, individuals living only from the time they are laid as eggs to their death after reproducing in the following year, or during that year's winter.

Individuals will typically have the opportunity to reproduce only once; however, they may occasionally succeed in raising two broods in a season, particularly in the warmer and longer spring and summer at the centre of the continent.

Following emergence from the ground, in the late summer or early fall of the year in which they were laid, the teneral (an adult recently eclosed from the pupa, and possibly capable of reproduction) begins feeding and possibly searching for reproductive opportunities. In the fall of its first year it will burrow into the ground to overwinter.

When the temperature permits in the spring, the adults will again emerge to feed and begin their evening search for a recently deceased suitable brood carcass, which they locate by smell from a distance of up to 3.5 km, using the chemical receptors at the ends of their antennae.

Reproduction is completely dependent upon the availability of the carcass resource and its successful entombment, which removes it from intense competition with other carrion eaters on the ground surface, and without which the species cannot reproduce. Vertebrate carcasses of any sort are employed (fish put on fields for fertilizer have been used, although natural access to them would be exceedingly rare); however, bird chicks and rodents are probably most often employed. The species tends to employ larger carcasses than its smaller congeners, and there is a correlation between the carcass weight and fecundity (the number and size of the larvae). Carcasses as small as 35 g (a mature Deer Mouse size, *Peromyscus maniculatus*) have been successfully employed, but 100 to 250 g (a half-grown Norway Rat size, *Rattus norvegicus*, full grown up to 485 g) is thought to be optimum for the species.

Both genders search separately for a suitable carcass, and when a male has located one it is possible that it broadcasts pheromones to attract a female. The individual or pairs will then compete with other carrion-eating insects, including conspecifics and congeners, for possession of the carcass until a single pair remains. Usually the larger individuals win this match, ensuring that if the American Burying Beetle is present it will take possession over any other insect species.

The pair, on their backs, lift the carcass from below with their legs to assess its weight. It may then be moved as much as a metre until soil suitable for excavation is reached (see **Habitat requirements**). The carcass will be buried before dawn by first ploughing the ground to loosen it, then digging under the carcass, ploughing the soil to the sides and severing roots, until it has reached the appropriate depth for the brood chamber. This depth is liable to exceed 20 cm for this species, greater than that for congeners due to the typically larger size of the carcass, with the concomitant necessity of masking its odour from carrion-eating animals and insects.

A brood chamber is excavated around the carcass, with a restricted exit tunnel to the surface. The beetle pair then prepare the carcass—it is worked and compressed into a compact ball, the fur or feathers are removed, and it is treated with anal and oral secretions to reduce decay and to dissuade colonization by other carrion-brooding insects (particularly fly maggots, order Diptera). A conical depression is formed on the top of the carcass under the escape tunnel to receive the newly hatched larvae, and the pair regurgitates drops of partly digested carrion into it to feed them.

The eggs are laid in the exit tunnel and after a few days the larvae hatch, fall onto the carcass, and begin feeding. The adults remain in the brood chamber in order to prevent it from being taken over by conspecifics, congeners, and invasive fly species, and their presence seems to be critical for larval survival. Often both parents remain with the larvae until they pupate, but sometimes only the female stays. Initially the adults feed regurgitated food to begging larvae, which grow rapidly until they are able to feed themselves. The adults will also cull the smaller larvae if the brood is too numerous for the carcass resource, and tend the carcass by removing fungi and continuously coating it with secretions to control bacterial growth. Broods of 3 to 31 larvae have been reported.

The flesh of the carcass will usually be consumed in about 1 week, and after the young burrow into the soil to pupate the adults abandon the brood chamber. The teneral adults eclose from the pupa and emerge from the ground about six to 8 weeks later.

Predation

Insectivorous animals, particularly canines, likely feed on adult American Burying Beetles. The Coyote (*Canis latrans*) is presumably a particularly significant predator on the species, and a competitor for the beetle's brood carcasses, and its range has expanded into eastern North America during the timeframe of the apparent extirpation of the beetle from many areas (Pederson 2004). Domestic dogs (*Canis lupus familiaris*) and cats (*Felis catus*) are also liable to be predators on adults and the carcasses. Jurzenski and Hoback (2011) describe findings that *Lithobates pipiens* feeds on *N. americanus*. These authors also mention predators such as Bluejays (*Cyanocitta cristata*), shrews (*Sorex* sp.) and Virginia Opossum (*Didelphis virginiana).*

The vertebrate composition of Block Island is depauperate compared to the mainland fauna (Raithel 1991), with a notable lack of scavenging and predatory mammals such as Raccoons (*Procyon lotor*), Virginia Opossum, mustelids (weasels), and canids. This has likely contributed to the success of the American Burying Beetle on the island (Raithel 1991),

The larvae are vulnerable to those animals that can detect the brood chamber and dig to it. Raccoons seem likely to be particularly effective at locating and excavating the brood chamber. The larvae may also be vulnerable to parasitic wasps, as are many larval insects, if the adult beetles cannot drive them off.

Food resources

American Burying Beetles must compete with other invertebrate species, as well as vertebrate species, for carrion (see **Predation** above).

Adults feeding

The species feeds primarily on the carcasses of vertebrates, particularly mammals and birds, but are also opportunistic scavengers in that they will evidently feed on any dead animal. They are also reported to consume live insects (Raithel 1991).

Brood carcasses

The species employs a larger size range of carcasses than its congeners (Raithel 1991); the greater the weight of the carcass, up to a limit thought to be ca. 250 g, the greater the brood fecundity. It is likely that abundance of the beetle is indicative of a significant population density of species which will provide carcasses of the optimal size as failed young or adults.

This condition is often present in bird colonies, or areas in which particular bird species of appropriate size are abundant and reproducing. Failed chicks will then provide abundant carcasses for the beetle's purposes. On Block Island, for example, the Ring-necked Pheasant (*Phasianus colchicus*), introduced in the 1920s, is abundant at a higher population level than on the mainland, and with a 35% nestling mortality undoubtedly contributes carcasses to the American Burying Beetle (Raithel 1991).

It is certain that the American Burying Beetle is not obligate over its full continental range to any particular species for its brood carcasses; however, it may be virtually obligate to a single species within a small area, such as a bird breeding colony.

Dispersal/migration

The American Burying Beetle is not migratory, but is capable of flight and moves over limited areas. It is unlikely that such a large, heavy species would be involuntarily blown significant distances by heavy winds, and its behaviour does not suggest susceptibility to that mechanism for dispersion. Raithel *et al.* (1991) found that for short-range flight *N. americanus* flew without regard to wind direction, but longer distance flights tended to be downwind. This suggests that wind is used to facilitate long-distance dispersion.

However, the species does range more widely, and likely through more habitat types, than its congeners in its search for carrion for feeding purposes and carcasses for brood purposes. For the latter, it likely searches much more widely than congeners (except in heavy aggregations of the supplying species, see **Food resources**), as carcasses of the appropriate size will tend to be much rarer than small bodies. For example, on Block Island, the number of carcasses < 100 g is at least a hundred times that of those heavier (Raithel 1991).

Creighton and Schnell (1998) found movement between sites of tenerals and adults of both genders of the species was ≥ 0.25 km/night, averaged 1.23 km/night, and was a maximum of 10.0 km over six nights, though presumably not in anything resembling a straight line. The possible distance of travel of the species during 1 month is therefore quite great, but the likely straight-line distance is very much smaller. These observations further support moderate vagility.

In addition, Creighton and Schnell (1998) found that the beetles moved readily within the habitat types at their area of study (grasslands, woodlands, bottomland and upland forests), suggesting that habitat requirements do not impose barriers on species' movement.

Adult activity period

Adults begin their seasonal activities when the temperature exceeds 15°C (60°F) (Raithel 1991), the date for which varies widely over their great latitudinal distribution and which is also influenced by proximity to the ocean.

The species is crepuscular and nocturnal (active in the evening and night), when the air temperature is high enough.

In general, they are active from April through September in areas relevant to Canada. On Block Island, Rhode Island, the species' reproductive period occurs in June and July (Raithel 1991), likely due to the moderation of temperatures by the ocean.

Interspecific interactions

The species is sympatric with its congeners *Nicrophorus marginatus*, *N. tomentosus*, and *N. orbicollis* (and possibly others such as *N. defodiens*, *N. pustulatus*, *N. sayi*, and *N. vespilloides)*, but readily discriminated by its larger size and the orange marking on the pronotum. Congeners do not likely compete with the American Burying Beetle, as its larger size ensures dominance at potential brood carcasses (Raithel 1991).

Nicrophorus species often carry orange mites (class Arachnida, family Parasitidae, genus *Poecilochirus*). The advantage that mites provide to the beetles is not known, but it is thought to be a phoretic (none-parasitic) relationship, which probably provides the beetles with advantageous grooming and reduces competition by fly larvae and microbe species for the carcasses, the mites gaining dispersion and feeding opportunities (Raithel 1991).

Adaptability

In the absence of a firm understanding of the mechanism(s) which have caused the historical decline of the American Burying Beetle in Canada, it is difficult to determine how adaptable the species is.

POPULATION SIZES AND TRENDS

Sampling efforts and methods

There is very good reason to have confidence in the conclusions of population decline in this species. The American Burying Beetle is unlikely to be overlooked by entomologists if it were present, due to its large size and brilliant colouration. In addition, it is unambiguous in determination to species. Few Canadian insects are so obvious and so likely to be encountered.

Since the start of decline about 50 years ago, the number of field entomologists in Ontario has probably increased by a factor of 10 at least (Arthropod SSC, pers. obs.). This should have increased the number of observations if the species had not declined, but instead there was a decrease. *Nicrophorus americanus* is also a member of a very well studied group. In Nova Scotia, for example, the Sexton Beetles (*Nicrophorus*) are one of the most well documented genera (C. Majka, pers. comm., 2003). Even in the absence of focused surveys, the species tends to be caught in pitfall and light traps—techniques very commonly used in general surveys for insects. We estimate that insect trapping events (trap nights) within the historical Canadian range of *N. americanus* over the past 50 years exceed 300,000 (Arthropod SSC, pers. obs.) and would very likely have led to the discovery of *N. americanus* if it was present yet there was only one record over this period and that was 39 years ago. The recent directed search (see above) to verify distribution, which resulted in no observation of *N. americanus*, supports the conclusion that this species has become extirpated in Canada..

Since the species was federally listed in the United States in 1989, there have been considerable efforts devoted to finding it, with some success in the Midwest, and some clear indications of its extirpation elsewhere. For example, in Ohio prior to its reintroduction it was not encountered in 100,000 trap nights of survey since 1992 (USDA 2008). This provides good evidence for extirpation in that state.

Abundance, fluctuations and trends

The dramatic decline in this high-profile invertebrate species was first commented upon by Davis (1980), and then Anderson (1982), who considered that the increased localization of the species *"was brought about solely through the activities of man"*.

It is estimated that there are fewer than 1,000 individuals in the currently disjunct Block Island population, and the two western populations each contain an unknown, though certainly much larger, number of individuals (Raithel 1991).

The diminishment of the range, locales, and abundance of the species was extraordinary in the last century. Wells *et al.* (1983) characterized it as *"one of the most disastrous declines of an insect's range ever to be recorded"*. For example, the species was once considered the most common of its genus in the town of Orient in New York State, but is no longer found anywhere in that state (Raithel 1991).

The reason for this dramatic decline has been considered in some detail by many authors, but there appears to be no consensus as yet (see **LIMITING FACTORS AND THREATS**). Regardless of the cause of the American Burying Beetle's historical decline, in the past quarter century there has been no report of reduction in numbers of insects or extirpation in any locale.

As a result of the fact that *N. americanus* has not been seen for 39 years and is believed extirpated, there is no continuing trend.

Rescue effect

Natural re-colonizing by the species of its former range in Canada appears to be very unlikely. The species is believed to have been extirpated from all states coterminous with Canada. The closest extant natural population in the east is Rhode Island, 400 km from the Canadian border in the Eastern Townships of Quebec. In the west, the closest extant population, South Dakota, is ca. 600 km from the border in Manitoba.

The species might be reintroduced from United States populations and captive breeding programs. Reintroduction is currently being attempted on Nantucket and Penikese islands in Massachusetts, and captive breeding programs are being conducted at Boston University, the Cincinnati Zoo, and in Oklahoma. There have been reintroductions since 1998 in Wayne National Forest, Ohio, which appear to have been successful (USDA 2008). Amaral *et al.* (1997) report that it was also successfully reintroduced to Massachusetts between 1990 and 1993.

LIMITING FACTORS AND THREATS

There is ongoing discussion regarding the cause or causes of the decline in the range and abundance of the American Burying Beetle. There are a number of hypotheses (Sikes and Raithel 2002), many of which are suspect due to the apparent lack of impact on congeners of similar behaviour and requirements. It seems unlikely that any one factor is responsible for the species' decline. In considering limiting factors and threats, it is appropriate to consider that there is likely no current Canadian population of the species so that these are potential threats that refer to a former population.

Direct impacts

The use of artificial lighting at night may possibly have confused the behaviour of the American Burying Beetle to the point of inhibiting reproduction (Raithel 1991); however, congeners have not apparently been impacted, certainly not proportionately.

Roadkill may be a factor in a species which travels fairly widely between habitats, particularly as those habitats become fragmented (see below). The presence of road-killed animals might draw the beetles to the roads, and hence expose them to the same threat. There was a massive increase in vehicle travel in the 1900s, and that increase was likely proportionately crepuscular and nocturnal. So an insect as large, slow-moving, and heavy as this beetle would be quite vulnerable to impacts, and unlikely to survive them; however, there is no evident reason why it would be more heavily impacted than its congeners except that it is more vagile than them in its search for larger brood carcasses.

The use of insecticides was initially considered a probable factor, but the timing of the insect's decline predates by as much as twenty-five years the extensive use of organochlorine compounds such as DDT, and some populations in the western range have survived that use. However, several populations in the Midwest disappeared at about the time of extensive DDT use (Raithel 1991). It is likely that insecticide use has been a contributor to the decline, though probably not the principal factor.

Disease

There has been some consideration of infection by naturally occurring or introduced pathogens, specific to *N. americanus*, but none are known to be specific to the species, and congeners appear unaffected (Raithel 1991).

Direct predation and competition

The natural absence of larger predators, which may consume adult beetles, is thought to be a factor in the American Burying Beetle's success on Block Island. Elsewhere, the fragmentation of habitat and increase in edge habitats such as hedges in developed areas likely increased the populations of these predators to the point where they have reduced American Burying Beetle adult populations. Species suggested as potential predators are (Raithel 1991): American Crow (*Corvus brachyrhynchos* Brehm 1822, though it is largely diurnal), Raccoon, Red Fox (*Vulpes vulpes* Linnaeus 1758), Virginia Opossum (increasing in abundance on the northern edge of its range), and the Striped Skunk (*Mephitis mephitis* Schreber 1776).

A significant impact probably originated in the extension of the range of the Coyote (*Canis latrans*) to the east from its pre-European colonization range almost entirely to the west of the known American Burying Beetle historical range. This range extension is thought to be anthropogenic, due to habitat fragmentation and construction of roads, which serve as travel corridors. The timeframe of this nocturnal predator's range extension east is very similar to that of the beetle's decline in the same areas. The impact of Coyotes on *N. americanus* may have been greater than on congeners because the larger size of the beetle and its brood carcasses would presumably be more attractive to the canines. However, the western range of the beetle does overlap to some extent with the historical range of the coyote.

Concomitant with the increase in human population, free-ranging or feral predacious pet species such as dogs and cats would certainly have exerted a strain on the adult beetles and their carcasses. Cats in particular, being largely nocturnal, likely take adult beetles.

It is notable that although this large species has so dramatically declined, its smaller congeners have not, even though it is more than capable of defending its interests against them, based on size. The extent of competition, however, remains unclear (Anderson 1982). It must compete for the carcasses with other carrion-using insects such as flies. If the competition pressure is too great at a particular locale the beetles will not be able to survive there.

Reduction of carcass resources

Reduction in the availability of the carcass resources necessary for reproduction in *N. americanus* would also be related to the abundance of predators, as most are also carrion eaters. Raithel (1991) pointed out that the reduction of carcass resources as the primary mechanism of decline is based on circumstantial evidence, although the timeframe of the decline is suggestive. In a fragmented ecosystem, larger species are negatively influenced before smaller species (Klein 1989).

Reduction in the number and abundance of the larger species that provide suitable brood carcasses, mostly failed chicks, has been postulated as a contributor to the decline of the American Burying Beetle. Extinction of the Passenger Pigeon, and severe decline of the Greater Prairie Chicken (*Tympanuchus cupido* (Linnaeus, 1758)) has almost certainly denied the beetle required carcass resources (Raithel 1991). Decline of other bird species of appropriate size is also recorded throughout the range.

Competition for carcass resources with other *Nicrophorus* species may have reduced the American Burying Beetle's reproductive success (Raithel 1991)—although the latter is larger and apparently tends to win competitions for carcasses, other species in the genus can be an order of magnitude or more abundant (their populations may grow as that of the American Burying Beetle declines). Regardless of the eventual outcome, competition with so many claimants would delay the process of burial, leaving the winning individuals and their brood carcass vulnerable to predators.

The increasing population of Essex County (approx. 4.9% over the past decade) suggests increased human impacts. Private dwellings, a large number of which are built in wooded areas thus reducing habitat, increased by 27.7% between 2001 and 2006. Roads currently used by 83% of the population to drive to work are likely increasing the number of confounding roadkills as well as reducing the general availability of carcasses elsewhere.

Habitat alteration and fragmentation

Anthropogenic habitat alteration and fragmentation are generally assumed to be the primary cause for the decline of the American Burying Beetle (Raithel 1991); however, the precise mechanisms and their relative impacts are still not fully understood, and virtually all the other mechanisms discussed above will be influenced by habitat change.

Forest clearing

Anderson (1982) believed that the clearing of primary forests in eastern North America was responsible for the species' extirpation there; however, its extant western populations are in areas where there is considerable agricultural development, though some forest remains in uplands. These western populations are in areas with abundant natural well-drained grasslands, which are suitable for the species and which are naturally rare in the east; therefore forest clearing may have affected the species most greatly in the east.

Habitat fragmentation

The breaking up of suitable habitat into small areas separated by unsuitable conditions is termed habitat fragmentation. This is a consistent phenomenon throughout the species' former range, and appears to be the most popular theory for the mechanism of the beetle's decline.

The three mechanisms stemming from habitat fragmentation which bear on the American Burying Beetle are: increased mortality due to the necessity to move between the remaining habitat fragments (predation, roadkill, and time taken from reproductive efforts), reduction of the abundance of the species contributing brood carcasses due to reduction of their breeding habitat, and increase in predation due to the greater extent of the habitat edges, which encourages greater abundance of predators.

Difficulty in burying

Any habitat change that increases the difficult of burying the brood carcass by altering the nature of the soil or its drainage will threaten the American Burying Beetle, which must succeed in interring the carcass before competitors take it.

One mechanism that increases the difficulty of burying is the growth of a heavy understory of bush and small trees, which increases the roots which must be cleared—this increase comes about from the clearing of mature forests. Additionally the accumulation of carcasses on compacted gravel beside roads due to roadkill may waste reproductive effort by attracting beetles to carrion that cannot be buried. Removal of upper soil layers by European earthworms may also have had an impact on burying capability.

SPECIAL SIGNIFICANCE OF THE SPECIES

The species, having been recognized as having suffered an extraordinary and presumably anthropogenic decline, offers the potential for enlightenment regarding human impacts on invertebrate species, and other ecological subjects.

The species offers a rich resource for behavioural study, particularly as it is a member of one of the few non-Hymenopteran insect groups that exhibit parental care. It is also of interest and under study with regard to the production of beneficial substances that eliminate bacteria and fungi.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Globally, the American Burying Beetle is listed in the IUCN Red List as Critically Endangered, subrank A1c, based on a population reduction of ≥90% and a decline in area of occupancy and occurrence (IUCN 2009).

In August 1989 it was federally listed as an Endangered Species in the United States through the U.S. *Endangered Species Act*, based on the drastic decline and extirpation of the species over nearly its entire historical range.

NatureServe (2009) ranks the species at G2G3 globally, rounded to G2 (imperiled), N2N3 nationally for the United States, and NH (historical) for Canada.

The species has not yet been assessed under the National General Status protocols for Canada (Wild Species 2009).

Table 1 gives current listing information by province and state.

ABORIGINAL AND TRADITIONAL KNOWLEDGE

No information has been found with respect to this particular species.

BIOGRAPHICAL SUMMARY OF REPORT WRITER

Paul Michael Brunelle has been studying the Odonata of Atlantic Canada and northern New England since 1987. He has authored a number of papers on the subject, and has proposed list statuses for Canada (NatureServe), all the Maritime Provinces, repeatedly, and for the State of Maine. He was invited to participate in the 2002 Odonata assessment for National General Status, and the recent revisions to General Status ranks for the Maritime Provinces. Brunelle established the Atlantic Dragonfly Inventory Program (ADIP) volunteer survey in the early 1990s. In 1997 he was retained by the State of Maine to plan the Maine Damselfly and Dragonfly Survey (MDDS), prepare its publications, give volunteer briefing seminars, and determine and input specimens. He was also retained to survey for rare Odonata species in the state. In 2000, Brunelle completed the description of the Broadtailed Shadowdragon (*Neurocordulia michaeli*) from New Brunswick, a new species discovered by him. Brunelle has entered more than 61,000 records in the ADIP/MDDS databases since their inception; more than 10,000 of which are from his own fieldwork. In 2007 he prepared the COSEWIC draft status report for *Ophiogomphus howei*, the Pygmy Snaketail.

Table 1A. Subnational distribution and conservation ranks east of the Red and Mississippi rivers. SRanks are from NatureServe (2009).

State/Province	SRank	Last	Locale	Comments
		Date		
Alabama	SH	–	Mobile	
Connecticut	SX	1920	Cornwall	
Delaware	SX	1897	New Castle	
Florida	SH	–	Marion	
Georgia	SNR	1940	Fulton	
Illinois	SH	1958	Johnson County	
Indiana	SH	1965	Posey County	
Kentucky	SX	1974	Trigg County	
Louisiana	SH	1928	Plaquemines	
Maine	SX	–	Oxford, Penobscot counties	
Maryland	SX	1947	Cambridge	
Massachusetts	S1	extant	Penikese Island	Reintroduced only
Michigan	SH	1961	Kalamazoo County	
Minnesota	SX	1931	Houston County	
Mississippi	SX	1949	Lafayette	
New Hampshire	–	1902	Rockingham	Not in NatureServe (2009)
New Jersey	SH	1919	Mercer	
New York	SH	1940	Long Island	
North Carolina	SH	1940	Black Mountain	
Ohio	SX	1920	Wayne	Reintroduced (USDA 2008)
Ontario	**SH**	**1972**	**Harrow**	
Pennsylvania	SH	1904	Philadelphia	
Rhode Island	S1	extant	Block Island	
South Carolina	SH	–	–	
Tennessee	SH	1955	various counties	
Virginia	SH	1896	Nelson	
Wisconsin	SX	1948	Shawano County	

Table 1B. Subnational distribution and conservation ranks west of the Red and Mississippi rivers.

State/Province	SRank	Last	Locale	Comments
		Date		
Arkansas	S1	extant	western	
Iowa	–	1932	Appanoose County	Not in NatureServe (2009)
Kansas	S1	extant	southeast	
Manitoba	**SNR**	–	–	In NatureServe (2009)
Missouri	SH	1980s	southwest	
Montana	–	–	–	Not in NatureServe (2009)
Nebraska	S1	extant	central	
Oklahoma	S1	extant	eastern	
South Dakota	S1	extant	southcentral	
Texas	S1	extant	northeast	

COLLECTIONS EXAMINED

Agriculture and Agri-Food Canada.* Dr. Whitefield, Science Director, Harrow, Ontario, Canada

American Museum of Natural History (AMNH).* Dr. Grimaldi

Canadian National Collection of Insects (CNCI). Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada, K1A 0C6. Raymond Hutchinson kindly reviewed this document.

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Lyman Entomolgical Museum (LEM). Stéphanie Boucher, Curator, Lyman Entomological Museum Macdonald Campus, McGill University, Ste-Anne-de-Bellevue, Quebec, Canada, H9X 3V9

Michigan State University (MSU).* Mark F. O'Brien New Brunswick Museum (NBM)

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Smithsonian Institution, National Museum of Natural History (NMNH). Jerry Louton, 10th Street at Constitution Ave, NW (West Loading Dock), NHB, MRC 165, Room CE-420, Washington, DC, United States, 20560; David G. Furth, MRC 165, P.O. Box 37012, Washington, DC, United States, 20013-7012

University of Guelph (UG).* Dr. Steve Marshall

* No response as of February 28, 2009.

Additional notes from Daniel Banville following an evaluation in Quebec:

Collection entomologique Musée Lyman (4 spécimens: 2 USA, 1 Guelph, 1 lieu inconnu)

Collection Robert-Ouellet (Université Montréal) (7 spécimens des USA)

Insectarium de Montréal (aucun spécimen)

Collection personnelle de Claude Chantal (aucun spécimen)

Collection de l'Université Laval (2 spécimens des USA) but no specimen for the province of Quebec of *N. americanus*.

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INFORMATION SOURCES

The principal reference for the American Burying Beetle is Raithel (1991), also referred to as the USF&W Recovery Plan. This paper summarized exhaustively the work on the species to that year. An overview of possible causes for the decline of the species is given in Sikes and Raithel (2002).

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Individuals/organizations

Atlantic Canada Conservation Data Centre (ACCDC). *No data available other than that provided by ADIP.* Sean Blaney, Botanist and Assistant Director, PO Box 6416, Sackville, New Brunswick, Canada, E4L 1G6.

Canadian Wildlife Service (CWS) – Atlantic Region. Kim Mawhinney, *A/Manager,* Population Conservation, 6 Bruce Street, Mount Pearl, Newfoundland & Labrador, Canada, A1N 4T3.

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Canadian Wildlife Service (CWS) – Québec Region. François Fournier, *Biologiste/biologist,* Direction de la conservation de l'environnement, Environnement Canada, 1141, route de l'Église, C.P. 10 100 8e étage, Sainte Foy, Québec, Canada, G1V 3W5.

Centre de données sur le patrimoine naturel du Québec – Fauna. Ministère des Ressources naturelles et de la Faune du Québec, Direction de l'expertise sur la faune et ses habitats, 880, chemin Ste-Foy, 2e étage, Québec, Canada, G1S 4X4.

Federal Biodiversity Information Partnership (chaired by the Canadian Museum of Nature).*Inquiry forwarded to Bob Anderson and François Genier.* Dr. Lynn Gillespie, *Research Scientist,* Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, Ontario, Canada, K1P 6P4.

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Ministere des Ressources naturelles et de la Faune du Québec – Fauna. Daniel Banville, *Biologiste,* Secteur Faune Québec, 2e étage, 880, chemin Sainte-Foy, Québec, Québec, Canada, G1S 4X4.

Nathalie Desrosiers, *Biologiste.*

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Northern Bioscience. Dr. Robert F. Foster, 363 Van Horne Street, Thunder Bay, Ontario, Canada, P7A 3G3.

Nova Scotia Department of Natural Resources (NSDNR). *No data available other than that provided by ADIP.* Mark F. Elderkin, *Species at Risk Biologist,* Department of Natural Resources, 136 Exhibition Street, Kentville, Nova Scotia, Canada, B4N 4E5.

Ontario Ministry of Natural Resources (OMNR). *Request forwarded to the Ontario Natural Heritage Information Centre.* Alan Dextrase, *Senior Species at Risk Biologist,* Species at Risk Section, Fish and Wildlife Branch, Natural Resource Management Division, Ontario Ministry of Natural Resources, P.O. Box 7000, Peterborough, Ontario, Canada, K9J 8M5.

Ontario Natural Heritage Information Centre (ONHIC). Michael J. Oldham, *Botanist,* Biodiversity Section, Fish and Wildlife Branch, Ministry of Natural Resources, 300 Water Street, 2nd Floor, North Tower, Peterborough, Ontario, Canada, K9J 8M5. Colin Jones, *Natural Heritage Project Zoologist,* Natural Heritage Information Centre, Biodiversity Section,

Parks Canada. *No data available.* Dr. Patrick Nantel, *Conservation Biologist,* Species at Risk Program, *Species Assessment Specialist,* Ecological Integrity Branch, 4th Floor, 25 Eddy Street, Gatineau, Québec, Canada, K1A 0M5.

* No response as of February 28, 2009.

Appendix 1. Details of Canadian Records of the American Burying Beetle.

Global

IUCN critically endangered A1c, NatureServe G2G3, 'rounded' to G2 = Imperiled.

Canada

NatureServe NH = Historic.

Comments on the current land use at the locales are based on viewing of air photos in Google Earth. No coordinates were found in the data, those given below are approximate within the cities and towns mentioned, they are not the locale of collection. The decimal coordinates in square brackets can be copied into Google Earth to view the air photos.

Manitoba

NatureServe SNR = Not Assessed. No information has been found with respect to the reported (NatureServe) presence of the species in Manitoba.

Nova Scotia

NatureServe SH = Historic.

The report regarding the presence of this species in Nova Scotia is widely considered to have originated in an error in Madge (1956). There is no other published evidence that the species has ever been recorded in the province save for one adult, no date or locale, with 'INHS' as the source (Illinois Natural History Survey?, Colin Jones data). The website for Illinois Natural History Survey contained no reference to the species in Nova Scotia (INHS 2009).

Ontario

NatureServe SH = Historic.

Chatham

Surrounded by heavy agricultural land use.

September 2 1930, collector: D. Arnott, one adult, deposited at Harrow ('Con?RepAg, Harrow, Ont.'). August 14 1936, collector: O.K., one adult, deposited at the University of Guelph.

Guelph

A moderately urbanized area today, surrounded by heavy agricultural land use. September 1930, collector: H.A. Gilbert, one adult, deposited at the Lyman Entomological Museum.

Hamilton

A heavily urbanized area today, surrounded by heavy agricultural land use. No date, collector unknown, one adult, deposited at the University of Guelph.

Harrow

Surrounded by heavy agricultural land use. August 6 1951, collector: E.J. LaRoux, one adult, deposited at Carleton University (Anderson 1982). September 2 1972, collector: R.E. Roughley, one adult, deposited at the University of Guelph (Anderson 1982).

Port Sydney

A largely forested area today, this locale is in the Boreal Shield Ecozone, *approximately 50 km north of the Mixedwood Plains Ecozone. Also spelled Port Sidney in some data.* No date, collector unknown, one adult, deposited at the Royal Ontario Museum.

Strathroy

Surrounded by heavy agricultural land use. August 1 1934, collector unknown, one adult, deposited at Harrow ('Con?RepAg, Harrow, Ont.'). No date, collector: H. Hudson, one adult, deposited at Harrow ('Con?RepAg, Harrow, Ont.').

St. Thomas

Surrounded by heavy agricultural land use. July 14 1925, collector unknown, one adult, deposited at the Canadian National Collection of Insects.

Toronto

A heavily urbanized area today. May 23 1896, collector unknown, adult (?), deposited at 'CU' (Carleton University?).

'Ontario'

No other locale, no date, collector unknown, one adult, deposited at the Lyman Entomology Museum.

Quebec

NatureServe – not listed.

Coaticook

Surrounded by heavy agricultural land use. July 1913, collector: J.-I. Beaulne, one adult, deposited at the "La collection d'insectes du Québec" at the Complexe scientifique (Québec).

> *"The identification of species is confirmed but all specialists with which I spoke told me that there are some doubt about the place where Mr. Beaulne found the specimen. For many observations made Mr. Beaulne (Lepidoptera, Coleoptera) the localization was doubtful and for some impossible as a result of distant collection localities indicated as collection sites on the same day. For Nicrophorus americanus many entomologists went to Coaticook trying to find this species or habitat and they found nothing."* (pers. comm., Nathalie Desrosiers, Biologiste, Ministère des Ressources naturelles et de la Faune, Secteur Faune, Québec, 2005).

Montréal

A heavily urbanized area today. No date, collector unknown, one adult, deposited at 'CMNH' (Canadian Museum of Nature) but according to François Génier (CMN) there is no specimen in CMN coming from Montréal nor elsewhere in the province of Québec.